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RUNNING HEAD: Habitual Instigation and Execution

Habitual Instigation and Habitual Execution:

Definition, Measurement, and Effects on Behaviour Frequency

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Statement of contribution

What is already known?

- Habit is often used to understand, explain and change health behaviour
- Making behaviour habitual has been proposed as a means of maintaining behaviour change
- Concerns have been raised about the extent to which health behaviour can be habitual

What does this study add?

- A conceptual and empirical rationale for discerning habitually instigated and habitually executed behaviour
- Results show habit-behaviour effects are mostly attributable to habitual instigation, not execution
- The most common habit measure, the Self-Report Habit Index, measures habitual instigation, not execution

Abstract

Objectives. 'Habit' is a process whereby situational cues generate behaviour automatically, via activation of learned cue-behaviour associations. This paper presents a conceptual and empirical rationale for distinguishing between two manifestations of habit in health behaviour, triggering selection and initiation of an action ('habitual instigation'), or automating progression through sub-actions required to complete action ('habitual execution'). We propose that habitual instigation accounts for habit-action relationships, and is the manifestation captured by the Self-Report Habit Index (SRHI), the dominant measure in health psychology.

Design. Conceptual analysis, and prospective survey.

Methods. Student participants (N = 229) completed measures of intentions, the original, non-specific SRHI, an instigation-specific SRHI variant, an execution-specific variant, and, one week later, behaviour, in three health domains (flossing, snacking, breakfast consumption). Effects of habitual instigation and execution on behaviour were modelled using regression analyses, with simple slopes analysis to test habit-intention interactions. Relationships between instigation, execution, and non-specific SRHI variants were assessed via correlations and factor analyses.

Results. The instigation SRHI was uniformly more predictive of behaviour frequency than the execution SRHI, and corresponded more closely with the original SRHI in correlation and factor analyses.

Conclusions. Further, experimental work is needed to separate the impact of the two habit manifestations more rigorously. Nonetheless, findings qualify calls for habit-based interventions by suggesting that behavior maintenance may be better served by habitual instigation, and that disrupting habitual behavior may depend on overriding habits of instigation. Greater precision of measurement may help to minimise confusion between habitual instigation and execution.

KEYWORDS:

Habit; automaticity; theory; behaviour

Introduction

The concept of 'habit' – whereby behaviour is automatically elicited by cues that consistently preceded previous performance (Verplanken & Aarts, 1999) – is often used to explain recurrent health behaviours (Gardner, 2015a). Unlike intentional action, generated through effortful deliberation, habitual action is activated via an impulsive system, whereby cues trigger learned context-behaviour associations, which guide responses rapidly, with minimal conscious input (Strack & Deutsch, 2004). As habit forms, action control is transferred to the impulsive system, so that actions become automatic, freeing cognitive resources for other tasks (Wood, Quinn, & Kashy, 2002). Theory predicts that, in associated contexts, habit will consistently elicit behaviour, and diminish the influence of intentions, such that behaviour may proceed despite low motivation (Triandis, 1977). These effects have prompted interest in habit formation as a mechanism for behaviour maintenance, and habit disruption for modifying ingrained behaviours (Rothman, Sheeran & Wood, 2009). Some commentators have questioned whether behaviour can be habitual (Maddux, 1997), as few actions are experienced as fully automated. This criticism assumes a conceptualization of 'habitual behaviour' as being automatically selected *and* performed to completion. This paper has two aims. We present, first, a conceptual analysis of 'habitual behaviour', which distinguishes between two manifestations of habit within behaviour, and second, proof-of-principle empirical evidence of the utility of this distinction for behaviour prediction.

What is 'habitual behaviour'? A conceptual analysis

Deconstructing 'habitual behaviour' requires a coherent definition of 'habit'. Portraying habit as a *form* of behaviour is incompatible with accounts of habit as a *determinant* of behaviour; 'habit cannot be both the behaviour and the cause of the behaviour' (Maddux, 1997, p336). Additionally, people can block unwanted habitual actions (Quinn, Pascoe, Wood, & Neal, 2010), suggesting habit does not directly generate behaviour, but rather an impulse which, unless frustrated, guides action (Gardner, 2015a, 2015b). Gardner (2015a) thus defined habit as '*a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations'* (p4). Within this definition, an 'impulse' is a schematic action representation which, unless overridden by competing impulses, guides behaviour outside awareness (West & Brown, 2013). This achieves a distinction between *habit*, a process, and *habitual behaviour*, a manifestation of that process in behaviour.

Understanding 'habitual behaviour' also requires understanding how 'behaviour' may be facilitated by habit. All actions can be broken down into sub-components. Action-phase models deconstruct action into sequential phases, originating prior to action selection and concluding in action completion or reflection on outcomes (e.g. Heckhausen & Kuhl, 1985; Schwarzer, 1992). The Rubicon model, for example, depicts phases of predecision (characterized by deliberating over which action to pursue, culminating in deciding to act), postdecision (deliberation over implementation of action, culminating in action initiation), and action (Heckhausen & Kuhl, 1985). Models of the cognitive structures underpinning behaviour portray action hierarchically, such that actions are composed of lower-level, subservient sub-actions (e.g., Cooper & Shallice, 2000, 2006). For example, 'going for a run' may be decomposed into sub-actions including 'putting on sneakers' and 'leaving the house', each of which can be decomposed further (e.g. 'putting on left sneaker', 'tieing laces', 'putting on right sneaker')[1]. People rarely consciously attend to lower-level actions: we mentally

[1] Viewing behaviour as a fractal creates an infinite regress, avoidance of which requires the assumption that there is a base level at which action should be conceived, such that analysis at a yet finer level is no longer directly relevant to understanding meaningful behaviour (e.g.

represent actions at high levels of abstraction, according to motives or intended consequences (e.g. 'visiting a friend'), rather than procedural intricacies (e.g. 'pressing the doorbell') (Vallacher & Wegner, 1987). These perspectives may be reconciled by proposing at least two action stages: *selection of action,* which in action-phase terminology entails the decision to act and, in cognitive terminology, activation of a high-level action schema; and *performance*, involving completion and termination of action, or the concatenated discharge of lower-level sub-actions.

Two corresponding accounts can be inferred from existing treatments of 'habitual behaviour'. The first describes habitual selection and initiation of behaviour (e.g., Verplanken & Melkevik, 2008): encountering a context (e.g. arriving home) automatically triggers a schematic representation of an associated, perceptually unitary action (e.g. going for a run), which, unless sufficiently opposed, translates directly into initiation (e.g. changing into running clothes). From this perspective, 'going for a run', for example, is habitual where the actor is automatically cued to select the 'going for a run' action unit, and begins enacting the sub-actions required to 'go for a run' (e.g. 'put on sneakers'). Within this account, habit facilitates movement from predecision into action, bypassing preactional deliberation (cf Verplanken, Aarts & van Knippenberg, 1997). We term this *'habitual instigation',* whereby *the habit process generates selection of a behavioural target, which, unless frustrated, instigates its realization into action*. Completion of the action subsequently proceeds via (habitual or non-habitual) activation of lower-level sub-actions. Potentially, any internal or external event may

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patterns of muscle activation). The cognitive modelling approach views the basic level of analysis as that of purposeful physical movements. For example, Cooper and Shallice (2000) decompose the discrete behavioural steps involved in 'preparing instant coffee' no further than the level of 'pick up', 'put down', 'tear', 'unscrew', and so on. This level of analysis is sufficient for the purposes of this paper.

trigger habitual instigation (Verplanken, 2005), though studies of what we deem habitual instigation have focused on location, time, mood, social, and preceding action cues (e.g., Wood et al, 2002).

A second account portrays habit as a facilitator of progression through an action sequence such that, after action selection, performance proceeds to completion through habitual activation of its sub-components (e.g. Graybiel, 1998). This form of habitual behaviour is akin to skill (Anderson, 1982): with repetition, low-level actions become perceptually 'chunked' into higher-order sequences which, after instigation, are discharged automatically (Graybiel, 1998). These sequences are 'habitual' in that, within a higher-order sequence (e.g. 'going for a run'), completion of a sub-action (e.g. 'put on sneakers'), or attainment of its consequences (e.g. sneakers are on), automatically activates another sub-action (e.g. 'leave the house'). In hierarchical terms, this habit manifestation operates at a finer-grained level of action than that of the triggered mental action representation. 'Going for a run', for example, would be habitual in this respect where progression through the sub-actions required to perform what the actor views as 'going for a run' is facilitated by habit. This manifestation locates habit within the Rubicon model's action phase and facilitates movement towards termination of action. We term this *'habitual execution'*, whereby *the habit process activates lower-level sub-actions subservient to a higher-order behavioural target, and so, unless enactment of any lower-level actions is frustrated, facilitates completion of the higher-order behaviour.*

FIGURE 1 HERE

Figure 1 applies the two manifestations to 'going for a run'. While both phenomena are underpinned by the same psychological process (i.e., habit), habitual instigation commits the actor to an action and typically instigates the first sub-action within the action sequence (e.g. 'put on sneakers'), whereas habitual execution facilitates progression through that sequence.

The instigation-execution distinction is implicit in extant empirical and theoretical habit literature, but obfuscated in explicit conceptualisations of 'habitual behaviour'. Neuroimaging shows that two sites are involved in habit formation, the infralimbic cortex being implicated in routine action selection (i.e. instigation), and the sensorimotor striatum in representation of steps required to discharge routine actions (execution; Smith & Graybiel, 2014). The Norman-Shallice model describes 'horizontal' triggering of action schemas (instigation), and subsequent 'vertical' (i.e. top-down) excitation of lower-level schemas (execution) (Norman & Shallice, 1986). Yet, Graybiel (2008, p361) defines habitual behaviour as *both* automatically triggered (habitual instigation) *and* automatically proceeding to completion (habitual execution). Aarts, Paulussen and Schaalma (1997) describe 'genuine habit formation' as involving both 'automatic decisions on courses of action *and* their subsequent execution' (p369, emphasis added). Two exercise habit measures incorporate both externally triggered activation (instigation), and invariance of exercise patterns (execution) (Grove, Zillich, & Medic, 2014; Tappe & Glanz, 2013).

The distinction between habitual instigation and execution has theoretical and practical implications. Habitual instigation does not necessitate habitual execution, nor vice versa. One person may habitually opt to 'go for a run' (habitual instigation), yet run mindfully, varying performance elements (e.g. route) to avoid boredom (non-habitual execution). Another may deliberate over whether to go running (non-habitual instigation), but not attend to the unfolding sequence (habitual execution). The distinction may be less practically relevant for behaviours composed of few observable sub-components, for which instigation and execution are less discernible (e.g. drinking water). However, many health behaviours, such as physical activity, are complex and rarely experienced as wholly automated (Maddux, 1997). Restricting 'habitual behaviour' to automatically instigated *and* executed action limits its explanatory value for complex action. Defining 'habitual behaviour' as *either* habitually instigated *or* executed recognizes both as potentially independent manifestations of habit.

We hypothesise that habitual instigation and execution reduce the cognitive demands of action in different ways. Habitual instigation operates analogous to an automated reminder to act, alleviating the mental burden of deliberation. Imposing the distinction retrospectively on previous studies, this concurs with evidence that, with context-dependent performance, activation of action becomes less reliant on external reminders (Tobias, 2009). By contrast, habitual execution makes procedural enactment smooth and efficient, so that people can better attend to matters unrelated to ongoing actions executed mindlessly (Wood et al, 2002).

Habitual instigation and habitual execution in action: An empirical study

A study was undertaken to demonstrate the distinction between habitual instigation and execution, and its relevance for understanding the extant literature around habitual health behaviour, using the behaviour-prediction methods that dominate this literature (Gardner, 2015a). Behaviour-prediction studies typically assess two effects: the correlation between habit strength and behaviour frequency, and an interaction whereby intentions are less predictive of frequency as habit strengthens (Labrecque & Wood, 2015). We suggest that both effects are attributable to habitual instigation, not execution. For example, habitual gym-goers repeatedly attend the gym because they are automatically cued to do so, not because they follow the same exercise routine in the gym (Phillips & Gardner, 2016). Conversely, one may habitually execute the same routine in the gym yet attend the gym infrequently (Gardner, 2012). Similarly, those with weak gym attendance intentions may be more likely to attend where automatically cued to do so. While habitual execution may correlate with frequency, because execution develops through repetition (Anderson, 1982), it is unlikely to directly *determine* frequency (Phillips & Gardner, 2016).

Existing habit measures do not discern instigation and execution. The only study of the two manifestations to date adapted non-specific items from the Self-Report Habit Index (SRHI, Verplanken & Orbell, 2003; 'Exercise…' [e.g. '…is something I do automatically']) to specify instigation ('*Deciding to* exercise*…*') or execution (e.g. '*Once I am exercising, going through the steps of my routine…*'; Phillips & Gardner, 2016). Instigation and execution loaded on discrete factors, and only instigation predicted exercise frequency, though measurement incompatibility arising from differently worded behaviours ('going through the steps of my routine' vs 'exercise') may have diminished execution-behaviour associations (Ajzen, 1988). Although the authors did not employ the originally-formulated SRHI for comparison, these findings suggest that the characteristic effects of habit on action frequency typically shown by the SRHI (Gardner, de Bruijn, & Lally, 2011) may be attributable to habitual instigation. Similarly, detailed planning of how, where and when to implement (i.e. instigate) action can enhance SRHI scores (Fleig et al, 2013; Orbell & Verplanken, 2010). Understanding previous findings depends on knowing which manifestation is captured by the SRHI .

This study was undertaken to address two research questions. First, is habitual instigation a stronger predictor of behaviour frequency than is habitual execution? Second, which of the two habit types is assessed by the SRHI? This study investigated whether effects on behaviour frequency can be attributed to habitual instigation rather than execution, and whether the SRHI captures instigation, execution, or some combination of both. To ensure findings were not behaviour-specific, three health behaviours were studied: breakfast consumption, as skipping breakfast has been associated with increased obesity and greater engagement in other health-compromising behaviours (e.g. Keski-Rahkonen, Kaprio, Rissnane, Virkkunen, & Rose, 2003); flossing, which combats bacteria build-up, which can otherwise cause cavities and gum disease (Bader, 1998),; and high-calorie snacking, which may contribute to weight gain and obesity (Forslund, Torgerson, Sjöström, & Lindroos, 2005).

To permit comparisons of our results with previous studies of habitual health behaviour, we adopted a prospective (one-week) questionnaire survey design with correlational analysis, which are the methods most commonly used in those studies (Gardner, 2015a). Undergraduate students were recruited, because we sought to model effects within an educated sample likely to recognise the instigation-execution distinction. Additionally, emerging adulthood is often characterized by health-risk behaviour (e.g., Nelson Laska, Pasch, Lust, Story, & Ehlinger, 2009), making variation in health behaviours and habit strength likely in this sample.

Hypotheses

Predicting behaviour frequency. Theory predicts that, where habit is strong, behaviour will be more frequently elicited, and intentions will have less predictive impact. We expected these effects to be attributable to habitual instigation. Thus:

Hypothesis 1: An instigation-specific SRHI variant ('instigation-SRHI') will correlate more strongly with behaviour frequency than will an execution-SRHI.

Hypothesis 2a: Instigation-SRHI will predict frequency when controlling for intention.

Hypothesis 2b: Adding an execution-SRHI over and above instigation-SRHI and intentions will not improve the predictive utility of the model.

Hypothesis 3a. Instigation-SRHI will interact with intention in predicting behaviour, such that, as habit strength increases, the relationship between intention and behaviour will diminish.

Hypothesis 3b: Execution-SRHI will *not* interact with intention in predicting behaviour.

Assessing the SRHI. We expected the non-specific SRHI to reflect habitual instigation, not execution. Thus, we predicted the non-specific SRHI would replicate instigation-SRHI effects, and show closer convergence with the instigation-SRHI:

Hypothesis 3c: The non-specific SRHI will interact with intention in predicting behaviour frequency, such that, as habit strength increases, the relationship between intention and behaviour will be attenuated.

Hypothesis 4: Instigation-SRHI will correlate more strongly with the non-specific SRHI than will execution-SRHI.

Hypothesis 5: Instigation-SRHI items will load predominantly on the same factor as non-specific SRHI items, whereas the Execution-SRHI items will load predominantly on a different factor to non-specific SRHI items.

Method

Participants, design and procedure

Psychology undergraduate students aged 18 or above were recruited, via a US college participant pool, to an online survey, for which they received course credits. They completed intention, and instigation, execution, and non-specific habit measures at Time 1 (T1)[2], and behaviour measures one week later (T2). Data were collected in

[2] Past behaviour was also assessed at baseline, using the same measure detailed below (number of days breakfast eaten: M = 5.91, SD = 2.18, observed range 0-7; days flossed: M = 3.22, SD = 2.53, observed range 0-7; days high-calorie snacks eaten: M = 4.79, SD = 1.87, observed range =

February-April 2014, with recruitment interrupted for two weeks during Spring Break, when typical behaviour would likely be disrupted (Wood, Tam, & Witt, 2005). Data collection was preplanned to run for one semester, to maximize chances of recruiting a sample sufficient to power analyses. Ethical approval was obtained (#011412).

Three hundred and nine students participated at T1, of whom 296 (96%) responded at T2. Thirteen non-responders to T2 did not differ on any variable from those who completed both time points ($p \geq .46$). Given the similar item wording, we included six items testing attention ('Please mark [e.g. strongly agree] as your answer to this question') (see Maniaci & Rogge, 2014). Of 296 who completed T2, 67 (22.6%) were excluded for answering incorrectly at least one of the six items. The final sample comprised 229 participants (193 [84%] female; age range 18-36y, mean = 20y, SD = 2).

Questionnaire

Intention and non-specific SRHI items were presented for all behaviours before Instigation and Execution SRHI items. To ensure attention to wording, after completing the former measures participants were randomly allocated with 50% probability to receive instructions, drawing explicit attention to the instigation-execution distinction, or telling them to expect alike items (see Supporting Information). Instruction condition (hereafter, 'condition') was controlled in all analyses, but had little impact on responses, correlating with only three of 48 possible items (maximum $r = .19$, $p = .004$).

Measures

Data were self-reported. Unless stated, response options ranged from 'strongly disagree' (1) to 'strongly agree' (7). Habit-intention-behaviour relationships may be inflated by measuring prointentional habits (Gardner, Corbridge & McGowan, 2015), so,

0-7) Patterns of results from correlation and regression analyses reported below were identical where past behaviour was the dependent variable.

while prointentional habits were measured for eating breakfast and flossing (e.g. flossing habit, intention to floss), habit measures were counterintentional for snacking (snacking habit, intention *to avoid* snacking). 'High-calorie snacks' were defined as 'high in fat or sugar, such as candy, sugar-sweetened beverages (e.g. soda, frappuccino), cookies, donuts, fries, and chips'. 'Breakfast' and 'flossing' were not explicitly defined.

Each *habit* variant (non-specific, instigation, execution) was measured by eight SRHI items ('[Behaviour X is something …] I do automatically', '…I do without having to consciously remember', 'I do without thinking', 'that makes me feel weird if I do not do it', 'that would require effort not to do', 'I would find hard not to do', 'I have no need to think about doing', 'I do before I realize I'm doing it')[3]. The latter item was amended from its original wording ('…I *start doing* before I realize I'm doing it'; Verplanken & Orbell, 2003, p1329), to permit a habitual execution adaptation. Four SRHI items relating to frequency and self-identity were excluded (see Gardner, Abraham et al, 2012). Instigation and execution stems were selected following Phillips and Gardner's (2016) pilot work among an independent group of 124 undergraduate students to identify face-valid indicators of the two habit types.

Non-specific SRHI item stems took the form '[flossing/eating breakfast/eating high-calorie snacks] is something…'. *Instigation-SRHI* stems were: 'Deciding to [floss/eat breakfast/eat high-calorie snacks] is something…'. 'Deciding' was used as a lay-friendly alternative to 'instigating', following Phillips and Gardner's (2016) pilot work showing college students to fully understand 'deciding' to be distinct from 'doing' (i.e. execution). *Execution-SRHI* stems were: 'Once I have decided to [floss/eat breakfast/eat high-

[3] The former four items comprise the 'Self-Report Behavioural Automaticity Index' (SRBAI), a reliable automaticity SRHI subscale (Gardner, Abraham et al, 2012). Patterns of results reported below did not change when analyses were run using the SRBAI in place of the SRHI.

calorie snacks], the act of [flossing/eating breakfast/eating high-calorie snacks] is something…'. All indices were reliable ($\alpha \geq .90$).

Following Ajzen (2006), two items measured *intention* ('I [intend to/plan to] [floss/eat breakfast/eat high-calorie snacks] on most days over the next 7 days'; $\alpha \geq .93$). *Behaviour frequency* was measured by a single-item: 'Over the last 7 days, on how many days did you [floss/eat breakfast/eat high-calorie snacks]?' [None – 7 days]).

Analysis

Analyses were run for each behaviour in turn. Normality was checked. Negatively skewed breakfast frequency ($z = -4.17$, $p<.001$), and positively skewed flossing frequency scores ($z = 4.69$, $p<.001$), were log-10 transformed (using reverse-ordered breakfast frequency values, and re-reversed transformed values for appropriate interpretation; Tabachnick & Fidell, 2007). Transformed values were less skewed (breakfast: $z = -1.20$, $p=.12$; flossing: $z = 2.73$, $p=.003$), and correlated highly with untransformed scores (r's = .97, $p<.001$), so were entered into analyses.

Comparison of correlation coefficients. Correlations, adjusted for condition, between SRHI variants and behaviour frequency (Hypothesis 1), and between SRHI variants (Hypothesis 4), were compared using Meng, Rosenthal and Rubin's (1992) formulae. Adjusted and unadjusted correlation coefficients differed negligibly ($\leq|.01$), indicating that condition had no impact on coefficients.

SRHI variants as predictors of behaviour frequency. Hypotheses 2a and 2b were tested in stepwise regression models, with condition, intention and instigation-SRHI entered at step one, and execution-SRHI at step two. Condition did not predict behaviour in any model ($p\geq.29$).

For each habit type, models were also run entering condition and intention at step one, and the SRHI variant at step two, to estimate variance explained by each variant unadjusted for other variants. Hypotheses 3a, 3b and 3c were tested by adding, at step three, an interaction term representing the product of means-centred SRHI and intention scores. Predictive interactions were deconstructed using simple slope analysis, modelling intention at one standard deviation (SD) below the mean SRHI score (weak habit), at the mean (moderate), and one SD above the mean (strong). To assess validity of interactions, the sample was deconstructed based on habit and intention scores, with those ≥1 SD below, ±1 SD, and ≥1 SD above the mean of each variable respectively treated as 'low', 'moderate', and 'high', generating nine (3 x 3) profiles.

Factor analysis of SRHI variants. Hypothesis 5 was tested in exploratory factor analyses (EFA) of the 24 items (8 items x 3 SRHI variants), using maximum likelihood extraction and direct oblimin rotation. EFA was used because we expected strong cross-loadings, which violates the independent cluster assumption of confirmatory factor analysis (Schmitt, 2011). Analyses met sampling adequacy and sphericity assumptions. Factor extraction was informed by parallel analysis (Horn, 1965). Loadings were extracted from the pattern matrix. (See Supplementary Table 1 for structure matrix .)

Power analysis

Power analyses were run with power at .80 and p<.05 (Faul, Erdfelder, Lang, & Buchner, 2009). The largest required sample for comparing correlations (hypotheses 1 and 4) was N = 130, assuming $r_{\text{instigation SRHI,execution SRHI}}$ = .85, $r_{\text{instigation SRHI,behaviour}}$ = .70, and $r_{\text{execution SRHI,behaviour}}$ = .50. For regression models (hypotheses 2a, 2b, 3a-3c), assuming medium effects for four predictors, N = 85 was required. We expected a two-factor structure (hypothesis 5), each with four or more loadings above .60, for which N=100 is sufficient (Guadagnoli & Velicer, 1988).

Results

Is habitual instigation a stronger predictor of behaviour frequency than habitual execution?

The instigation-SRHI consistently correlated more strongly with behaviour frequency ($r \geq .51$) than did execution-SRHI ($r \geq .32$; $Z \geq .3.79$, p's<.001; Table 1), supporting Hypothesis 1.

TABLE 1 HERE

For each behaviour, in models at the first step (Model $F \geq 33.38$, $R^2 \geq .31$, p's<.001), intention ($\beta \geq .|25$, p's<.001) and instigation-SRHI predicted behaviour ($\beta \geq .32$, p's<.001; Table 2). Execution-SRHI did not alter any model ($\Delta R^2 \leq .01$, $\Delta F \leq 0.09$, $p \geq .77$), nor did it predict behaviour (β's = -|.02), supporting Hypotheses 2a and 2b.

TABLE 2 HERE

Controlling for intention, with the exception of flossing execution SRHI ($\beta = .08$, $p = .18$), each SRHI variant was predictive ($\beta \geq .19$, $p \leq .001$; Table 3, Step 2, all models), though instigation-SRHI models (Model $F \geq 33.38$, $R^2 \geq .31$, p's<.001) appeared to explain more variance than execution-SRHI models (Model $F \geq 19.73$, $R^2 \geq .21$, p's<.001).

TABLE 3 HERE

No SRHI variant interacted with snacking intention (Model $F \geq 14.75$, $R^2 \geq .21$, p's <.001; Table 3, Step 3, all models). For eating breakfast and flossing, only the execution SRHI variant interacted with intention (Model $F \geq 65.86$, $R^2 \geq .54$, all p's <.001; $\beta = .13$, $p \leq .009$), habitual execution *strengthening* the intention-behaviour relation. Intention had greater impact where habit was strong, than moderate or weak (respectively, breakfast: βs = .79, .68, .56; flossing: βs = .77, .64, .51; all p's<.001). Profiling showed minimal variation in breakfast intention, with 73% of the sample reporting intentions within ±1 SD of the mean, but greater variation in flossing profiles, suggesting effects were valid (Supplementary Table 2). Hypotheses 3a, 3b and 3c were not supported.

Does the non-specific SRHI assess instigation or execution?

The non-specific SRHI consistently correlated more strongly with instigation-SRHI ($r \geq .84$) than with execution-SRHI ($r \geq .57$; $Z \geq 7.53$, p's<.001), supporting Hypothesis 4.

For breakfast and flossing, two intercorrelated factors were generated ($r \geq .65$; Table 4). While three factors emerged for snacking, items predominantly loaded on the first two. For all behaviours, non-specific and instigation items consistently loaded on the first factor only, and execution on the second only, supporting Hypothesis 5.

TABLE 4 HERE

Discussion

Habit may manifest in behaviour in two ways, automatically triggering pursuit of behaviour (habitual instigation), or progression through the sub-actions required to complete behaviour (habitual execution). Across three behaviours, associations between the Self-Report Habit Index (SRHI) and action frequency were more attributable to habitual instigation than execution, though execution unexpectedly strengthened intention-behaviour relations where instigation did not. Item responses suggested that the SRHI primarily captured instigation. Compatibly worded measures eliminated the possibility of measurement error influencing execution-action relationships. While more rigorous research is needed to demonstrate more compellingly the instigation-execution distinction, findings call for greater conceptual precision in understanding and measuring habitual behaviour.

We propose that habitual instigation acts as an automated contextual reminder to act (cf Tobias, 2009). We hypothesised that habitual instigation would account for well-documented effects whereby habit correlates positively with frequency, and diminishes the impact of intentions on behaviour (Gardner et al., 2011; Triandis, 1977). Indeed, stronger associations with behaviour were found for an instigation-specific SRHI variant than an execution variant, echoing work showing habitual instigation to better predict exercise frequency (Phillips & Gardner, 2016). No moderation was found using any variant for snacking. For breakfast consumption and flossing, moderation was observed using the execution index only, though intentions became *more* predictive of behaviour where habit was strong. While unexpected, these results are not unprecedented: several SRHI-based tests have either not shown moderation, or shown habit to *reinforce* the intention-action link (see Gardner, 2015a). A possible explanation for inconsistent previous findings is that habitual execution enables acting on intention where instigation does not. 'Chunking' sub-actions into an automated chain of procedural elements makes performance easier (Anderson, 1982), so bolstering self-efficacy (Bandura, 1977), in turn facilitating acting on intention (Conner & McMillan, 1999). While mostly tapping instigation, factor intercorrelations imply that the SRHI may at least partly capture habitual execution. Studies showing habit to strengthen intention-behaviour relationships may thus have captured effects of habitual execution rather than instigation. Alternatively, observed interactions may represent methodological artifice arising from strong positive correlations between intentions and prointentional habits (e.g. habitual flossing, intention to floss; Gardner, 2015a). Interactions have not been found between counterintentional habits and intentions, which correlate less strongly (e.g., Gardner et al, 2015). Caution is required when interpreting interplay between habitual execution and intention; replication in habit-intention conflict settings is warranted.

Our results suggest that habit-behaviour relationships may be attributable more to automatically cued activation of behaviour, not the automaticity with which an action sequence unfolds. This has important practical implications. Behaviour maintenance may be facilitated through development of habitual instigation (Kaushal & Rhodes, 2015), and need not involve automation of procedures of sub-actions. Forming both habitually instigated and executed responses may maximize the likelihood of maintenance (Aarts et al, 1997), but full automation may be an unrealistic target for many behaviours. This does not mean that habitual execution does not support action. Building a habitually executed sequence could indirectly promote maintenance, as chunking fosters mastery (Anderson, 1982), making behaviour more attractive (Bandura, 1977). Conversely, targeting habitual execution can stop unwanted actions. Disruption of ongoing action raises procedural elements into awareness (Vallacher & Wegner, 1987), allowing for conscious termination of the sequence. For example, a habitual smoker may be interrupted after activating their 'smoking' routine but prior to lighting a cigarette (Orbell & Verplanken, 2010). For behaviours that are both habitually instigated and executed however, in-flow disruption would not address instigation; the smoker that interrupts execution in one context may succumb to temptation in others, due to habitual instigation. Lasting discontinuation may be better facilitated by dismantling associations that activate action pursuit, rather than blocking execution.

Relative to an execution-specific SRHI variant, an instigation SRHI variant was more strongly correlated with, and loaded most highly on the same factor as, the original, non-specific SRHI. Inter-factor correlations were however strong. This is unsurprising, because the two habitual responses can develop in concert (Smith & Graybiel, 2014). However, strong correlations could also reflect participants' confusion about the proposed distinction. Participants' comprehension was not explicitly evaluated, so potential noise within the measures cannot be estimated. Nonetheless, the predictive utility of the instigation-specific SRHI suggests that habitual instigation and execution may respectively be captured by reflecting on to what extent 'deciding' to act, and 'having decided, actually doing' an action, is habitual.

Our study sought to illustrate the importance of discerning between habitual instigation and execution using an SRHI-based behaviour-prediction design among a student sample, the methodological limitations of which are well-documented (Gardner, 2015a). The validity of self-reported habit has been questioned, as people cannot reliably reflect on non-reflective processes (Hagger et al, 2015; Labrecque & Wood, 2015). Self-report may also be differentially sensitive to the two habit manifestations; people rarely attend to procedural components of chunked actions (Vallacher & Wegner, 1987), and so habitual execution may perhaps be less reliably self-reported than instigation. These problems may have been compounded by our purposeful recruitment of a highly-educated sample able to comprehend the instigation-execution distinction. Future work, ideally using non-student samples, might compare our items against less subjective habit measures, such as recall of sequential procedures (Judah, Gardner, & Aunger, 2013), or implicit association tests (Labrecque & Wood, 2015). ‘Think aloud’ methods might assess whether participants’ comprehension matches that of researchers interpreting the data (Gardner & Tang, 2014). An additional problem inherent to self-report is inattentive responding, which can distort effects (Maniaci & Rogge, 2014). Participants were required to discern subtly different wordings of similar items, and we excluded those responding inaccurately to any of six attention-testing items. Whilst this is likely to have minimized contamination of effects, the consequent exclusion of nearly a quarter of our sample illustrates the potential magnitude of this problem within self-report surveys.

Further investigations of the instigation-execution distinction require more sophisticated and rigorous methods than were used in the present study. Lab-based experimental designs, in which habits are manipulated within tightly controlled conditions, may more reliably separate instigation and execution of action. Longitudinal studies, in which behaviour change temporally precedes habit change, also offer opportunities to explore differences in the formation or disruption of habitual instigation versus execution patterns.

This study demonstrated, using the most popular research design, the potential to discern between habitual instigation and execution, and for habitual instigation, not execution, to direct action frequency. Further theory development will however require moving beyond the self-report survey model.

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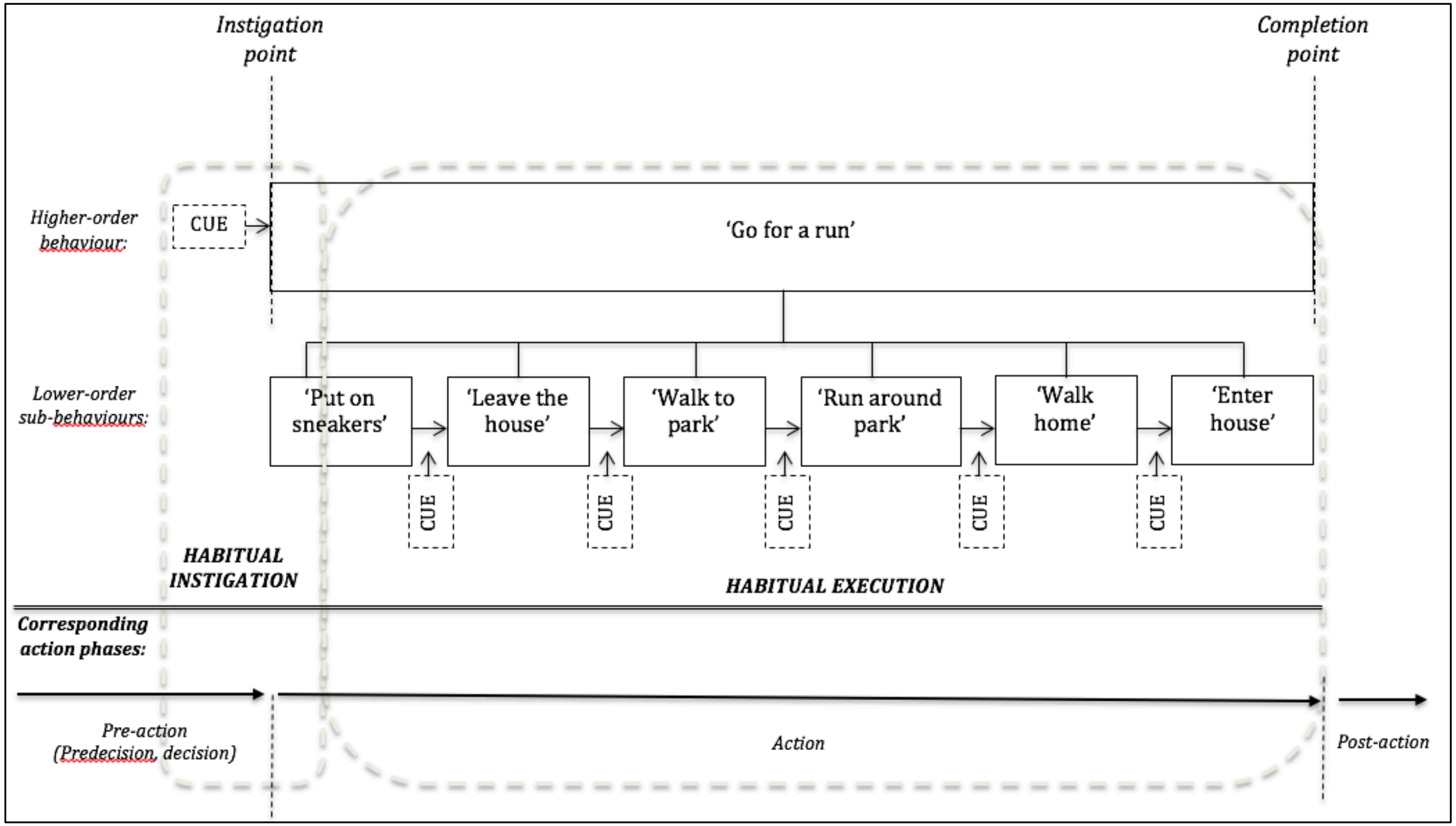
Figure 1. Habitual instigation versus execution for 'going for a run'



NB: Instigation and completion points refer to instigation and completion of 'going for a run', not of its sub-behaviours. Incorporation of only part of the 'put on sneakers' sub-behaviour within Habitual Instigation indicates that only initiation of 'putting on sneakers', and not necessarily its completion, may be enacted as part of the Habitual Instigation.

Table 1. Descriptives and correlations

	2.	*3.*	*4.*	*5.*	*Observed range*	*Mean*	*SD*	*α*
Eating breakfast (n = 229)								
1. Behaviour frequency (no. days on which breakfast eaten) (T2) †	.75	.72	.55	.73	0-7	5.92	2.14	-
2. Non-specific SRHI (T1)		.90	.70	.75	1-7	4.00	1.81	.95
3. Instigation SRHI (T1)			.73	.75	1-7	4.33	1.81	.96
4. Execution SRHI (T1)				.58	1-7	5.14	1.45	.94
5. Intention (T1)					1-7	5.32	2.02	.98
Flossing (n = 228)								
1. Behaviour frequency (no. days on which flossed) (T2) †	.69	.68	.49	.72	0-7	3.19	2.43	-
2. Non-specific SRHI (T1)		.94	.64	.77	1-7	2.59	1.70	.96
3. Instigation SRHI (T1)			.64	.73	1-7	2.68	1.74	.97
4. Execution SRHI (T1)				.61	1-7	4.24	1.67	.96
5. Intention (T1)					1-7	3.88	2.11	.97
Eating high-calorie snacks (n = 228)								
1. Behaviour frequency (no. days on which high-calorie snacks eaten) (T2)	.57	.51	.32	-.42	0-7	4.68	1.80	-
2. Non-specific SRHI (T1)		.84	.57	-.52	1-6.5	3.35	1.36	.90
3. Instigation SRHI (T1)			.61	-.39	1-7	3.58	1.48	.93
4. Execution SRHI (T1)				-.26	1-7	4.35	1.47	.93
5. Intention (T1) ‡					1-7	4.69	1.78	.93

NB: Correlations are adjusted for group allocation. All coefficients significant at p<.001. † For breakfast and flossing behaviour frequency, correlation coefficients are reported for transformed values, and means and SDs reported for untransformed values. ‡ For high-calorie snacking, intention refers to intending *to avoid* high-calorie snacking. SRHI = Self-Report Habit Index. T1, T2 = Time 1, Time 2.

Table 2. Instigation and execution SRHIs as predictors of behaviour frequency

Step	*Eating breakfast (n = 229)*		*Flossing (n = 228)*		*Eating high-calorie snacks (n = 228)*	
	Step 1 Beta	*Step 2 Beta*	*Step 1 Beta*	*Step 2 Beta*	*Step 1 Beta*	*Step 2 Beta*
1. Intention	.42***	.42***	.49***	.49***	-.25***	-.25***
Instigation SRHI	.41***	.40***	.32***	.33***	.41***	.42***
2. Execution SRHI		.01		-.02		-.02
R^2	.60	.60	.57	.57	.31	.31
Model F	114.53***	85.52***	98.85***	73.86***	33.38***	24.95***
R^2 *change*		.00		.00		.00

NB: All models control for group allocation, which had no relationship with behaviour (p's ≥.29). *** p<.001. All other p's>.05. SRHI = Self-Report Habit Index.

Table 3. Non-specific, Instigation and Execution SRHIs as moderators of intention-behaviour frequency relationship**.**

	All models	*Non-specific SRHI*		*Instigation SRHI*		*Execution SRHI*	
Step	*Step 1 Beta*	*Step 2 Beta*	*Step 3 Beta*	*Step 2 Beta*	*Step 3 Beta*	*Step 2 Beta*	*Step 3 Beta*
Eating breakfast (n = 229)							
1. Intention	.73***	.38***	.41***	.42***	.50***	.62***	.68***
2. Habit		.46***	.45***	.41***	.39***	.19***	.20***
3. Habit x intention			.04		.10		.13**
R^2	.53	.63	.63	.60	.61	.55	.57
Model F	128.51***	124.85***	93.54***	114.53***	87.86***	93.43***	73.71***
R^2 *change*		.05***	.00	.07***	.01	.02***	.01**
Flossing (n = 228)							
1. Intention	.72***	.47***	.50***	.49***	.52***	.67***	.64***
2. Habit		.33***	.27**	.32***	.25**	.08	.12*
3. Habit x intention			.06		.07		.13**
R^2	.52	.57	.57	.57	.57	.53	.54
Model F	123.08***	98.39***	73.91***	98.85***	74.70***	82.98***	65.86***
R^2 *change*		.05***	.00	.05***	.00	.00	.02**
Eating high-calorie snacks (n = 228)							
1. Intention	-.41***	-.16*	-.17*	-.25***	-.25***	-.35***	-.35***
2. Habit		.48***	.48***	.41***	.41***	.21***	.21***
3. Habit x intention			.03		.04		-.02
R^2	.17	.33	.33	.31	.31	.21	.21
Model F	22.85***	37.33***	27.96***	33.38***	24.94***	19.73***	14.75***
R^2 *change*		.16***	.00	.14***	.00	.04***	.00

NB: All models control for group allocation, which had no relationship with behaviour frequency (minimum p = .29).
*** p<.001, **≤p.01, *p≤.05. All other p’s>.05. SRHI = Self-Report Habit Index.

Table 4. Exploratory factor analyses of non-specific, Instigation and Execution SRHIs

	Eating breakfast (n = 229)		*Flossing (n = 229)*		*Eating high-calorie snacks (n = 229)*		
	Factor 1	*Factor 2*	*Factor 1*	*Factor 2*	*Factor 1*	*Factor 2*	*Factor 3*
Non-specific SRHI ('Behaviour X is something…')							
'I do automatically'	.92		.94		.76		
'I do without having to consciously remember'	.87		.97		.82		
'that makes me feel weird if I do not do it'	.93		.85		.54		
'I do without thinking'	.89		.95		.86		
'that would require effort not to do'	.88		.77		.53		
'I do before I realize I'm doing it'	.66		.88		.79		
'I would find hard not to do'	.81		.85		.42		.41
'I have no need to think about doing'	.71		.72		.57		
Instigation SRHI ('Deciding to do Behaviour X is something…')							
'I do automatically'	.90		.96		.87		
'I do without having to consciously remember'	.86		.97		.86		
'that makes me feel weird if I do not do it'	.89		.87		.63		
'I do without thinking'	.88		.94		.81		
'that would require effort not to do'	.79		.83		.65		
'I do before I realize I'm doing it'	.78		.90		.67		
'I would find hard not to do'	.85		.86		.56		.46
'I have no need to think about doing'	.66		.80		.61		

Execution SRHI (‘Once I have decided to do Behaviour X, the act of Behaviour X is something…’)							
‘I do automatically’		.84		.91		.84	
‘I do without having to consciously remember’		.87		.93		.85	
‘that makes me feel weird if I do not do it’		.66		.82		.57	
‘I do without thinking’		1.04		.98		.89	
‘that would require effort not to do’		.78		.80		.67	*.49*
‘I do before I realize I’m doing it’		.65		.84		.77	
‘I would find hard not to do’		.70		.76		.67	*.50*
‘I have no need to think about doing’		.81		.82		.74	
Eigenvalue	15.42	2.06	16.03	2.95	12.01	2.69	1.48
% variance explained	64.25%	8.60%	66.80%	12.31%	50.02%	11.19%	6.15%
Correlation between Factors 1 & 2	.74		.65		.54		

Emphasis added to higher loadings. Loadings extracted from pattern matrix. Loadings <.40 not reported. All extracted factor eigenvalues exceeded those randomly generated by parallel analysis (Factor 1 [F1]: 1.28; F2: 1.18, F3: 1.15). SRHI = Self-Report Habit Index.

Supplementary Table 1a. Sample profiles underpinning habitual execution x intention interaction, breakfast consumption (N = 229)

		Intention			*Row total*
		≥1 SD below mean N (%)	*Mean N (%)*	*≥1 SD above mean N (%)*	
Habitual execution	*≥1 SD below mean N (%)*	19 (8%)	12 (5%)	0 (0%)	*31 (14%)*
	Mean N (%)	33 (14%)	118 (52%)	0 (0%)	*151 (66%)*
	≥1 SD above mean N (%)	0 (0%)	47 (21%)	0 (0%)	*47 (21%)*
Column total		*52 (23%)*	*177 (73%)*	*0 (0%)*	

Supplementary Table 1b. Sample profiles underpinning habitual execution x intention interaction, flossing (N = 229)

		Intention			*Row total*
		≥1 SD below mean N (%)	*Mean N (%)*	*≥1 SD above mean N (%)*	
Habitual execution	*≥1 SD below mean N (%)*	20 (9%)	15 (7%)	0 (0%)	*35 (15%)*
	Mean N (%)	19 (8%)	98 (43%)	36 (16%)	*153 (67%)*
	≥1 SD above mean N (%)	4 (2%)	11 (5%)	26 (11%)	*41 (18%)*
Column total		*43 (19%)*	*124 (54%)*	*62 (27%)*	

Supplementary Table 2. Structure matrix from exploratory factor analyses of non-specific, Instigation and Execution SRHIs

	Eating breakfast (n = 229)		*Flossing (n = 229)*		*Eating high-calorie snacks (n = 229)*		
	Factor 1	*Factor 2*	*Factor 1*	*Factor 2*	*Factor 1*	*Factor 2*	*Factor 3*
Non-specific SRHI (‘Behaviour X is something…’)							
‘I do automatically’	**.86**	.60	**.93**	.60	**.76**	.42	
‘I do without having to consciously remember’	**.88**	.66	**.94**	.59	**.78**		
‘that makes me feel weird if I do not do it’	**.86**	.59	**.87**	.59	**.52**		
‘I do without thinking’	**.90**	.67	**.94**	.61	**.84**	.46	
‘that would require effort not to do’	**.84**	.60	**.77**	.50	**.66**	.45	**.52**
‘I do before I realize I’m doing it’	**.72**	.56	**.90**	.60	**.80**	.47	
‘I would find hard not to do’	**.79**	.57	**.86**	.57	**.58**	.45	.54
‘I have no need to think about doing’	**.73**	.54	**.74**	.49	**.61**		
Instigation SRHI (‘Deciding to do Behaviour X is something…’)							
‘I do automatically’	**.90**	.66	**.95**	.60	**.89**	.51	
‘I do without having to consciously remember’	**.90**	.69	**.94**	.59	**.87**	.51	
‘that makes me feel weird if I do not do it’	**.89**	.65	**.90**	.61	**.64**		
‘I do without thinking’	**.91**	.69	**.93**	.59	**.88**	.56	
‘that would require effort not to do’	**.85**	.66	**.83**	.54	**.75**	.48	.51
‘I do before I realize I’m doing it’	**.82**	.63	**.90**	.58	**.76**	.51	
‘I would find hard not to do’	**.84**	.62	**.88**	.59	**.70**	.47	.60
‘I have no need to think about doing’	**.77**	.63	**.80**	.52	**.66**	.41	

Execution SRHI *('Having decided to do Behaviour X, the act of Behaviour X is something…')*							
'I do automatically'	.63	**.85**	.51	**.86**	.50	**.87**	
'I do without having to consciously remember'	.64	**.87**	.56	**.90**	.56	**.89**	
'that makes me feel weird if I do not do it'	.63	**.77**	.57	**.84**	.44	**.65**	
'I do without thinking'	.59	**.91**	.56	**.93**	.51	**.89**	
'that would require effort not to do'	.65	**.84**	.59	**.84**		**.74**	.63
'I do before I realize I'm doing it'	.59	**.73**	.60	**.87**	.47	**.80**	
'I would find hard not to do'	.65	**.80**	.61	**.84**		**.74**	.64
'I have no need to think about doing'	.60	**.81**	.57	**.85**	.43	**.73**	
Eigenvalue	15.42	2.06	16.03	2.95	12.01	2.69	1.48
% variance explained	64.25%	8.60%	66.80%	12.31%	50.02%	11.19%	6.15%
Correlation between Factors 1 & 2	.74		.65		.54		

Emphasis added to higher loadings. Loadings extracted from structure matrix. Loadings <.40 not reported. All extracted factor eigenvalues exceeded those randomly generated by parallel analysis (Factor 1 [F1]: 1.28; F2: 1.18, F3: 1.15).

Instructions given within questionnaire, prior to Instigation and Execution SRHI items

Condition 1 (explicit attention drawn to instigation-execution distinction):
“The following questions distinguish between deciding to do an action and actually doing that action. For example, 'drinking coffee' involves first deciding to drink coffee, and then actually consuming the coffee. 'Eating a candy bar' requires deciding to eat a candy bar, and then actually eating the candy bar. Please read each question carefully before answering.”

Condition 2 (participants informed to expect alike items):
“You may find some of the following questions to be similar. However, please read each question carefully before answering.